
Space Weather Technical Forecast

Issued on Sunday, 17 April 2022 at 13:02 Local

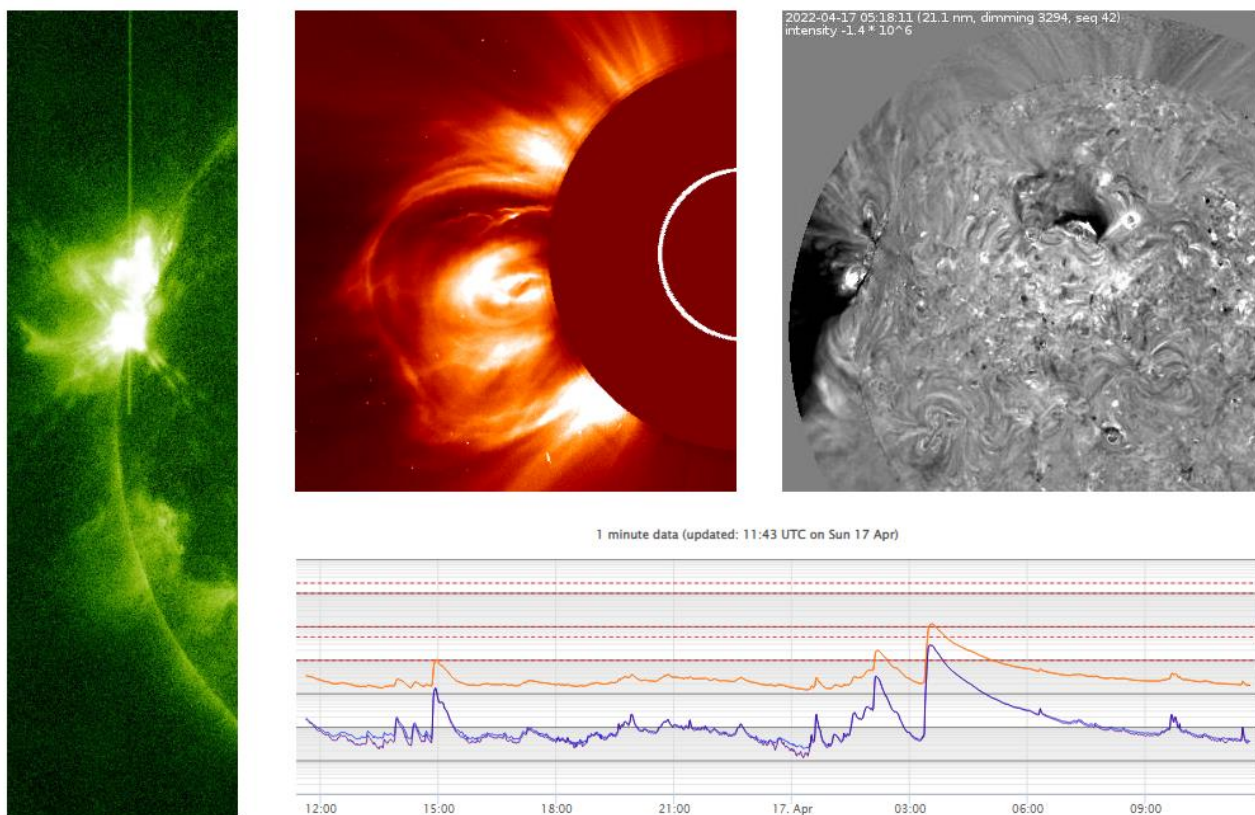
This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: M-class flares Likely throughout (R1/R2 Radio Blackouts). Active Electron Fluence soon becoming Likely.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity became High in the past 24 hours, with an X1.1 X-ray flare observed at GOES16, peaking at 17/0331UTC. This emanated from the newly-arrived AR2994 in the northeast quadrant. This event was associated with a Type-II radio burst and an estimated ejecta velocity of 614km/s. A moderately fast-moving CME was in evidence in available coronagraph imagery, however cursory analysis suggests that this is likely to pass behind the track of the Earth in its orbit to no effect.

Figure 0: Clockwise from left: AIA 094 image of 17/0311UTC X1.1 flare; resultant Lasco C2 CME; time-integrated view of AIA 211 dimming (from SIDC ROB); GOES 16 X-ray flux.



There are currently five numbered sunspot groups on the Earth-facing side of the sun, including the aforementioned AR2994. This region occupies a particularly busy portion of the disc, which may yet prove still more densely populated when the viewing angle improves, with far-side imagery

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suggesting further detail may arrive this UTC weekend. For now, AR2994 appears as an Ehi/Beta-Gamma. To its immediate north, there is at least one and possibly two groups, currently amalgamated into AR2993, a Dhi/Beta. These groups dominate the current disc in terms of areas and complexity, however there were two other regions of note: firstly AR2992 in the southwest, which grew from plage to attain Cro/Beta by the period's end; while AR2991 showed some slight intermediate spot proliferation but maintained its Dri/Beta class. The final group on the disc was AR2990, a simple, stable unipolar Hax/Alpha in the southeast.

A possible disappearing filament was seen just prior to 17/0500UTC from the vicinity of AR2990 - although any flare from this event was swamped by the declining flux of the earlier X-class. Imagery will be monitored for any ejecta, however there is none in evidence at the time of writing. There were some peripheral (i.e. limb-generated) Coronal Mass Ejections (CMEs) in the period, the largest and most notable of which was generated by the aforementioned X-flare. The possible mobile filament mentioned in earlier guidance does not appear to have left the immediate solar environment, meaning at present there are thought to be no Earth-directed CMEs in available imagery.

Solar Wind / Geomagnetic Activity: The solar wind, as observed by DSCOVR and ACE at L1, continued to be Elevated due to ongoing fast wind influence of CH74, with the phi angle accordingly mostly positive (away from the sun).

The solar wind speed showed an overall slight decline in the 24 hours, falling from near 550km/s to reach the high-400s of km/s by the end of the period. The density trace was somewhat erratic for switching data sources, however it resided at or below 10ppcc throughout. The IMF peaked at 8nT, while the north-south component varied between -7 and +6nT.

The net result of the above solar wind measures was Quiet to Unsettled, with provisional peak Kp observed through the early hours UTC in the form of two successive intervals of '3o'.

Energetic Particles / Solar Radiation: The high energy proton flux (10 MeV) measured at GOES-16 at GEO was at Background levels, with no discernible response from the X-class flare, perhaps because of its eastward location.

The high energy electron flux (greater than 2 MeV) showed a slight rise in its diurnal trend in the period, varying between Moderate and High levels and peaking at 1230pfu at 16/1650UTC. The associated 24-hour electron fluence has been below the Active threshold throughout, but showing a rising trend, with observed fluence of 3.98e7 integrated pfu at 17/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is Likely to be Moderate through the period, primarily due to active region AR2994 and perhaps also AR2993 that have recently rotated onto the northeast disc. There is a daily Slight Chance of further X-class flares. No significant groups leave the disc in the four days, however the northeastern limb may yet be bolstered by further arrivals - with detail to follow.

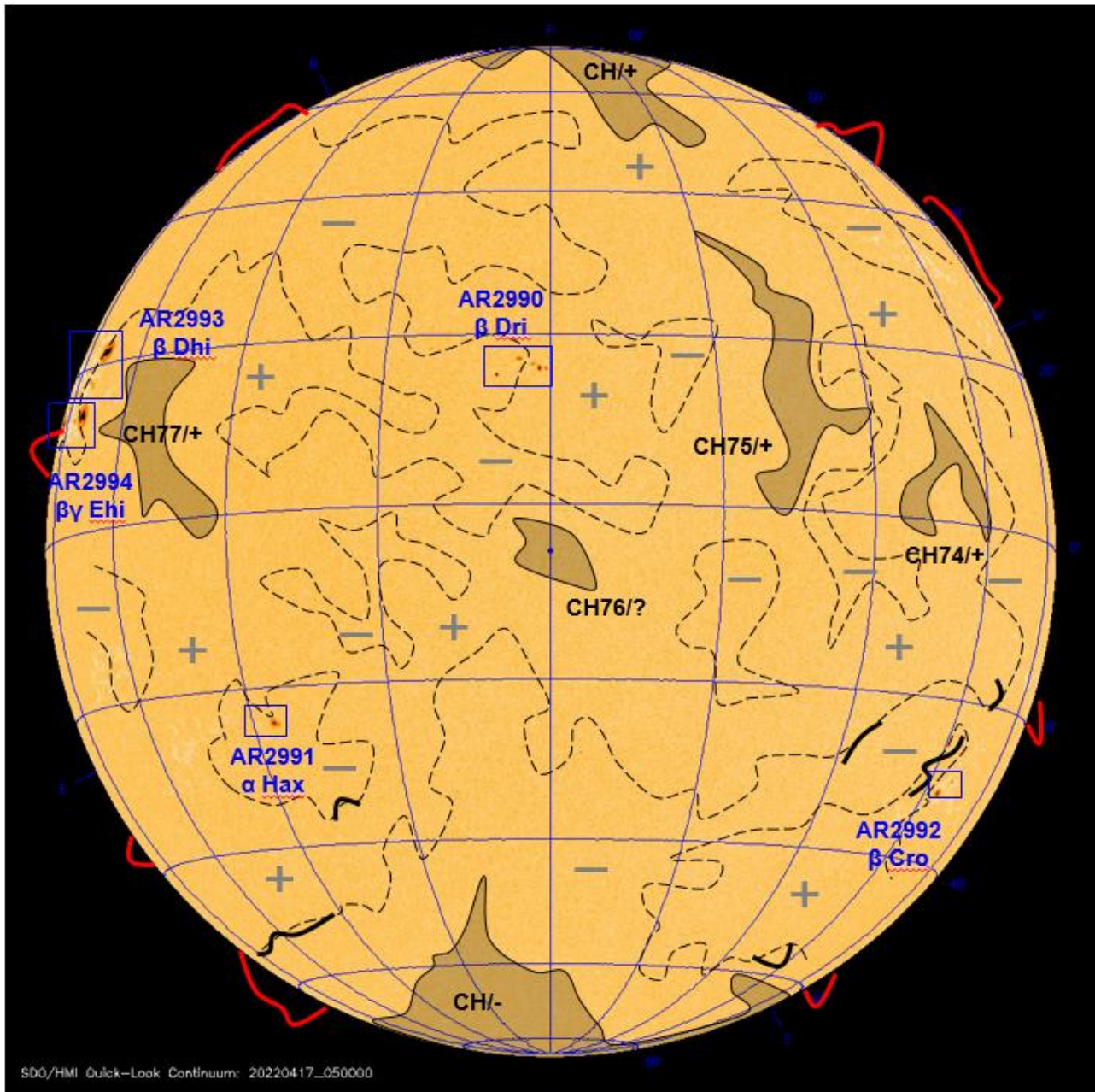
Solar Wind / Geomagnetic Activity: There are no Earth-directed CMEs in the current forecast. Earth is embedded within the fast wind of CH74/+ and expected to see further fast wind enhancement through the period from CH75/+ on days 1-2 (Sunday 17 and Monday 18 April) and then CH76/- later in the period, most likely day 4 (Wednesday 20 April). However, confidence is low regarding the strength and timing of these enhancements. Quiet to Active geomagnetic activity is forecast, with a daily Slight Chance of G1/Minor Storms, probably peaking on day 4.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to be at Background levels, with just a slight increase in probability by the end of the period as AR2993 and AR2994 move westwards across the Earth-facing solar disc.

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The high energy electron flux (greater than 2 MeV) is expected to persist at Moderate to High levels, although drop-outs are likely from any fast wind arrivals, significantly reducing confidence by day 3 (Tuesday 19 April). The associated 24-hour electron fluence is likely to rise above the Active (1e8 pfu) threshold later day 1 or day 2 (Sunday 17 and Monday 18 April), before likely declining due to any drop-outs, with a gradual decay of peak flux levels.

Figure 1. Solar Analysis Valid 17/0500UTC.



Key: Filament ____, Prominence ____, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α - β - $\beta\gamma$ - $\beta\gamma\delta$ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

There are no Earth-directed CMEs in the current forecast.

Earth is currently in the fast wind from CH74, with solar winds currently elevated at around 500km/s. A brief easing of the solar wind is possible over the remainder of the current UTC day (Sunday 17 April) before the arrival of the fast wind of CH75 is likely to cause a resurgence before day three. These solar winds should then potentially ease again, before a further fast wind arrival is possible Wednesday 20 April, from the small CH76/- centre disc. The timing and strength of these features are low confidence however, with only the final of the three holes featuring in persistence data, while the ever-decreasing upwind sampling (in the Parker spiral) from STEREO-A is not providing any useful steer for being out-of-range.

Geomagnetic activity is forecast to be mostly Quiet to Active, with fast wind enhancements through the period giving a daily Slight Chance of G1/Minor storms on days 1-3 (17-19 April). Chances are perhaps slightly lower on day three, but are maintained a 5% G1 for the increasing uncertainty. Finally, the period is rounded out by a potentially greater risk on day 4, when a recurrent coronal hole arrives (CH76).

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	5	5	5	20
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil.

Radio Blackouts - X-Ray Flares:

Solar Activity is Likely to be Moderate, with a likelihood for M-flares (R1/R2 Radio blackouts) on each day, primarily from new active regions in the northeast. These also bring a Slight Chance of isolated X-class flares (R3 radio blackouts). This is now slightly increased above suggested raw values for the current sunspot's (AR2994) obvious active history (today's X1.1 but also the long-period M2 while still over the limb, which is felt to be a underestimate for the flux). As previously noted, further complexity is expected to become apparent as they rotate into full view, with their current analysis likely to change. This is supported by STEREO-A EUVI 195 imagery which shows a broad area of bright flux, and magnetic looping in the northeast disc, along with notable magnetic looping visible in SDO AIA products.

Finally, regarding the balance of active regions on the disc, only AR2992 is expected to leave the Earth-facing side in the period, and this does not contribute appreciably to the risk of large flares - the daily chances of flares are therefore held static throughout, pending (any) arrivals to analyse over the eastern limb.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	70	70	70
Very Active	R3 to R5 X Class	Yes	20	20	20	20

Figure 2: View of northeastern limb at 07/1100UTC, showing (from left to right) HMIIF of AR2993 (top) and AR2994 (bottom); HMIBC; AIA 171.

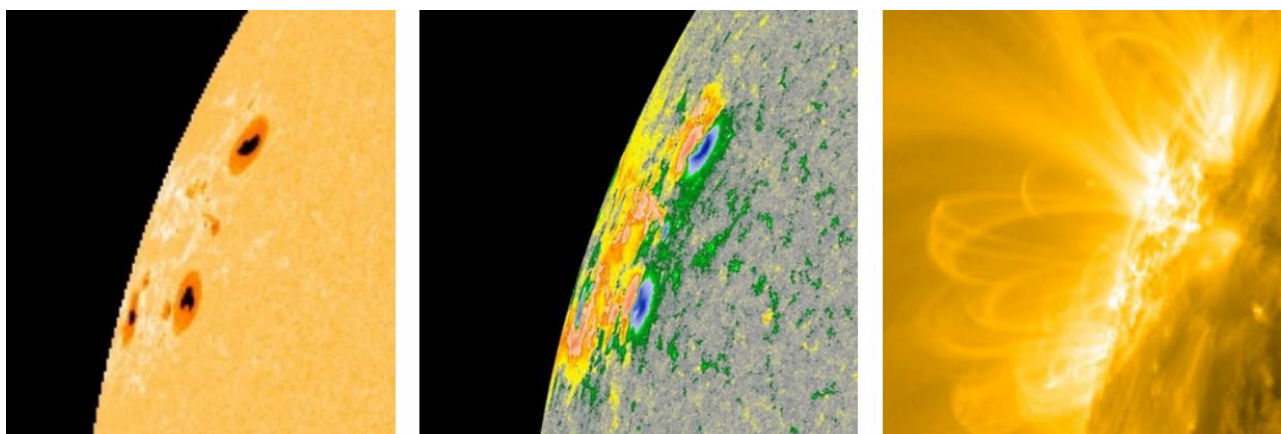
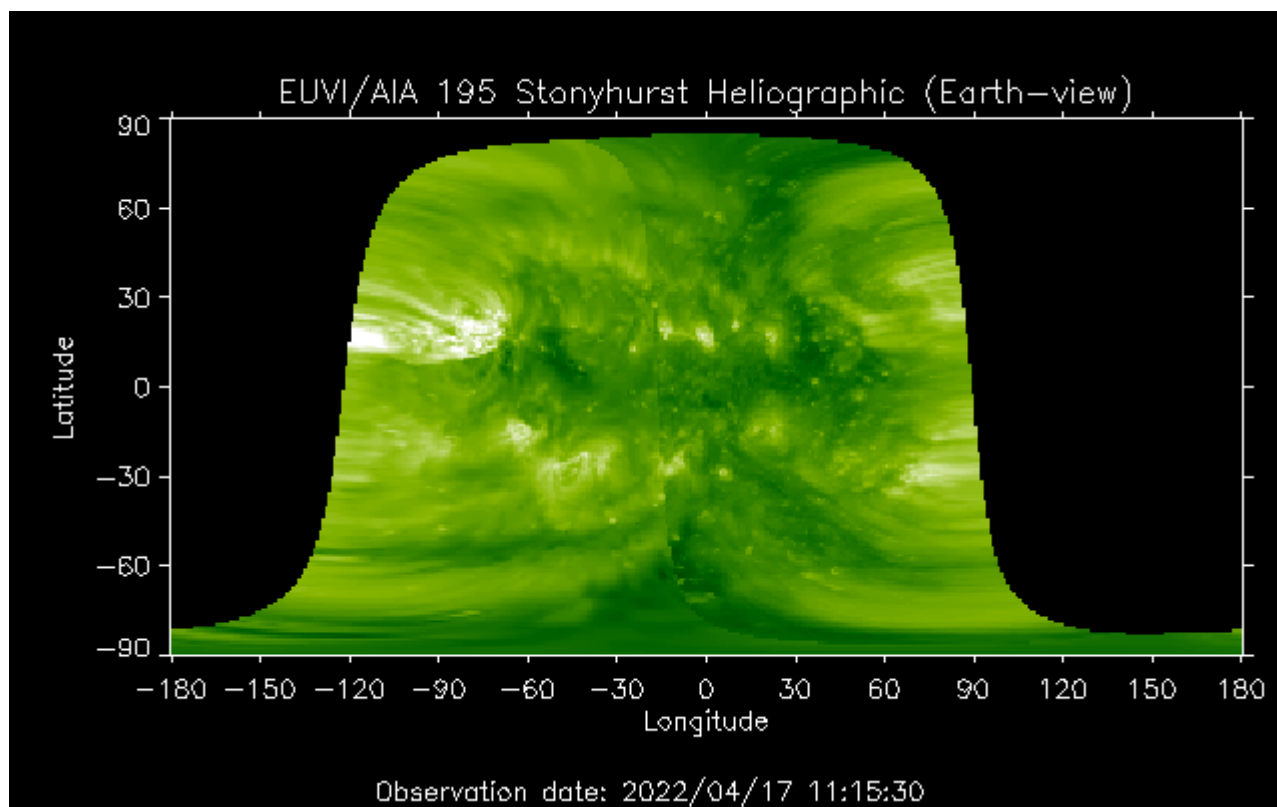


Figure 3: View of upcoming northeastern horizon bright flux regions in EUVI 195 imagery.



Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as measured by GOES-16 at GEO is at background levels, and is most likely to remain so through the next four days. New regions in the northeast have the potential to be followed by a further region(s) associated with Ex-2975 and/or Ex-2976, which had a history of producing S1 proton events on the previous rotation. As they continue to move into a slightly more favourable location for any such proton events to be observed by Earth, the potential for S1 or above storms increases, albeit still only very slightly.

Radiation Storms	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq \text{S1}$	No	1	1	2	2
Very Active	$\geq \text{S3}$ *	No	1	1	1	1
* S3 $\geq 10 \text{ MeV} \geq 1000 \text{ pfu}$ and / or $\geq 50 \text{ MeV} \geq 10 \text{ pfu}$. (pfu = $\text{cm}^{-2} \text{sr}^{-1} \text{s}^{-1}$)						

High Energy Electrons Event ($\geq 2\text{MeV}$):

The high energy electron flux (greater than 2 MeV) as observed by GOES-16 at GEO has risen to a higher baseline in the past 24 hours to peak at High levels. Peak values are expected to rise through day one (Sunday 17 April), but likely continuing Moderate to High through the period. Drop-outs are possible with induced geomagnetic activity as successive fast wind arrivals occur, although the timing and strength of these are low confidence. Recovery of flux levels are likely to follow any falls, but with decreased confidence for reaching High levels, especially from day three (Tuesday 19 April).

The associated 24-hour electron fluence is currently rising, with REFM giving good guidance for the expected trend, although observations are currently running higher than forecast. Consequently Fluence is likely to rise above the Active ($1\text{e}8$) threshold day one, peaking day two (Monday 18 April), before declining again. However confidence becomes low by day three, with potential fast wind arrivals and subsequent flux falls possible.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	40	70	60	40
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1

Figure 4: Top to bottom: MOSWOC REFM 3-day fluence forecast (blue dots) and observed values (black), showing expected upward trend; 72-hour electron flux at GOES 16; L1 solar wind speed. The diurnal oscillation ought to increase in the coming hours as geomagnetic activity lessens and the delayed reaction to the L1 solar wind speed takes effect.

